Distances in space

- **astronomical unit**: distance from Earth to Sun

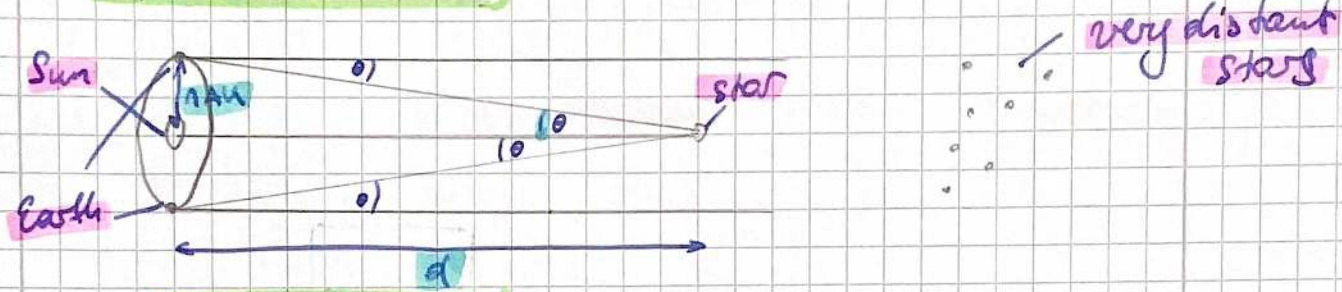
$$1\,AU = 1{,}5 \cdot 10^{11}\,m$$

- **light year**: distance that light passes in one year

$$1\,ly = 9{,}5 \cdot 10^{15}\,m$$

- **parsec**: parallax angle of one second → parallax method (works up to 100pc)

$$1\,pc = 3{,}08 \cdot 10^{16}\,m$$



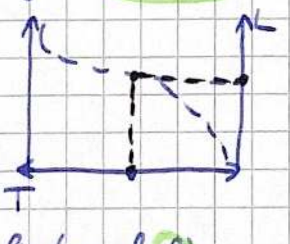
$$\tan(\theta) = \frac{1\,AU}{d}$$

$$d = \frac{1}{p}$$ ← p: parallax angle in seconds

$$1^\circ = 60' = 3600''$$

$$d = 1\,pc \iff \theta = 1''$$

- **spectroscopic parallax** (works up to 10 Mpc)
  - → measure b
  - → measure spectrum → get λ_{max} → Wien's law → get T
  - → use H-R-diagram →



→ $d = \sqrt{\frac{L}{4 \cdot \pi \cdot b}}$ (see definition of b)

BRUNNEN

Luminosity and magnitude

Luminosity: total power emitted by star

$L = \sigma \cdot A \cdot T^4$ ← in °K $[L] = W$

→ Stefan-Boltzman-law

Apparent Brightness: power received on Earth per m^3

$B = \frac{L}{4 \cdot \pi \cdot d^2}$ $[B] = W/m^2$

↖ distance to star

Apparent magnitude: measure for B on inverse log scale

$m = -19 - \frac{5}{2} \cdot \log(B)$

- naked eye can see up to $m = +6$

Absolute magnitude: apparent magnitude at a distance of 10pc

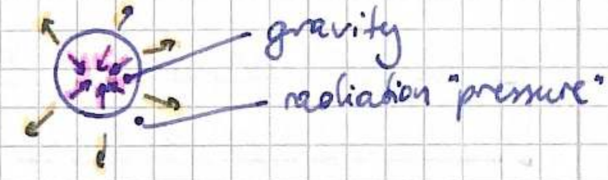
$\frac{B_1}{B_2} = 2{,}51^{m_2 - m_1}$ ($2{,}51 = \sqrt[5]{100}$)

$\frac{L_1}{L_2} = 2{,}51^{M_2 - M_1}$

$m - M = 5 \cdot \log\left(\frac{d}{10}\right)$ ← distance in pc

Stars

hydrostatic equilibrium



Binary stars

- **visual**: seen in telescope
- **spectroscopic**: seen in wavelengths due to Doppler
- **eclipsing**: seen through "dip" in Brightness

nucleosynthesis: creation of different nuclei in the star

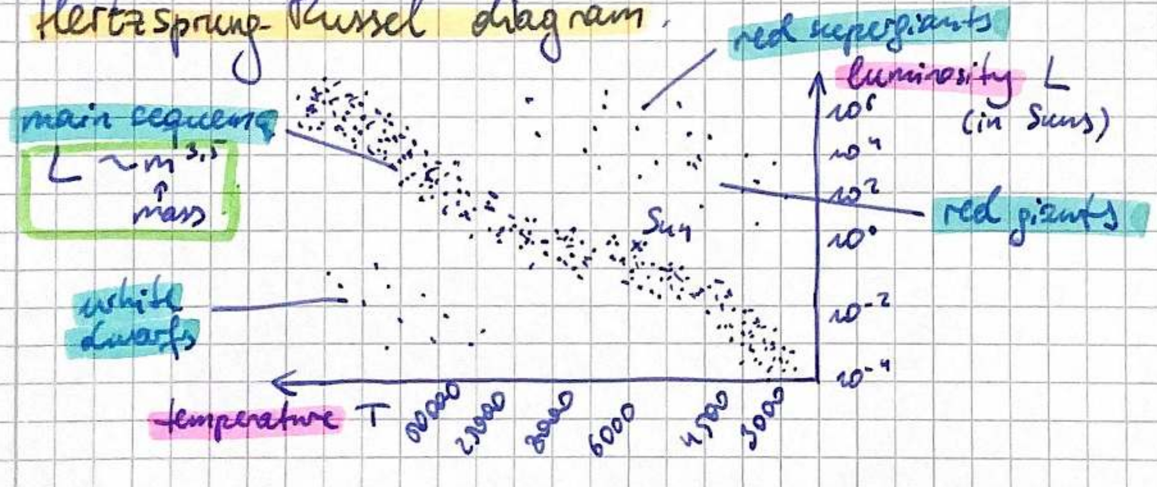
- **proton-proton-cycle**:

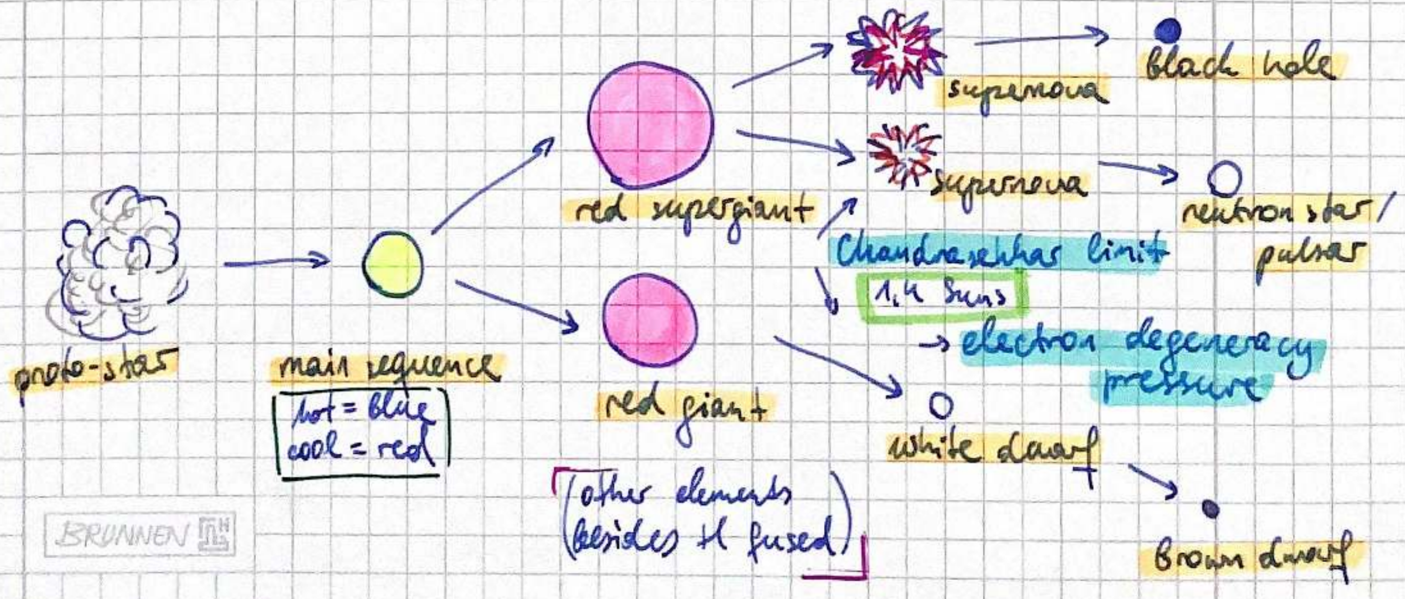
$$ {}^{1}_{1}H + {}^{1}_{1}H \rightarrow {}^{2}_{1}H + {}^{0}_{1}e^{+} + {}^{0}_{0}\nu_e $$

$$ {}^{2}_{1}H + {}^{1}_{1}H \rightarrow {}^{3}_{2}He + {}^{0}_{0}\gamma $$

$$ {}^{3}_{2}He + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + 2 \times {}^{1}_{1}p $$

Hertzsprung-Russel diagram





Cepheid variables

- star that periodically contracts and expands
- larger luminosity = larger period
- used to estimate distance to galaxies, in which c.v.-s are located

Expanding universe

Cosmic microwave background (CMB) radiation

isotopic (same in all directions) microwaves coming from a theoretical black body (=universe itself) with $T = 2{,}73\,°K$
(all directions)

space is expanding → wavelengths get larger:

$$Z = \frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

- Z ← red shift
- $\Delta\lambda$ ← change in wavelength
- λ ← original wavelength
- v ← velocity of star
- c ← speed of light

Hubble's law: $v = H_0 \cdot d$

- H_0 ← Hubble const
- d ← distance from Earth
- v ← speed of galaxy/star

age of universe: $T = \frac{1}{H_0}$